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AUTHOR(S): Glenn Morris, Q-12
Los Alamos Scientific Laboratory

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DROUGHT AND ENERGY RESOURCE DEVELOPMENT IN NEW MEXICO

by

Glenn Morris, Q-12
Los Alamos Scientific Laboratory
Los Alamos, New Mexico 87545

ABSTRACT

This paper reviews the current relationship between water resources and energy development in New Mexico, with special emphasis on the San Juan and western Rio Grande basins. It examines the various ways in which the water used in energy extraction and processing may be acquired by the energy developer. Both supply side and demand side options are explored and the conclusion is drawn that the source of water which is most attractive to the developer will be that which may be bought in the water market.

The paper goes on to examine what this strategy would mean for New Mexico in the near future. It suggests that price competition for water would have only a minor impact on agricultural production if extensive future energy developments focused on the proposed coal-fired steam-electric plants and coal extraction for export by rail. This conclusion, however, rests upon two assumptions: that water markets operate efficiently and that there exists an enlightened public water policy.

DROUGHT AND ENERGY RESOURCE DEVELOPMENT IN NEW MEXICO

by

Glenn Morris

Drought, as defined by an economist such as myself, is the relative scarcity of water. That is, water is in short supply relative to the potential beneficial uses to which it may be put. This scarcity of water resources will become more acute in New Mexico as the population and economy of the state grow. My talk today will review the alternative ways in which energy developers can solve their problems as water consumers in a semi-arid state. In so doing, I hope to indicate the way in which these solutions impact the broader water management problems faced by state officials and, ultimately, by us as citizens.

Allow me to begin by sketching the scope of what I will refer to here as the water dimensions of energy development in New Mexico. First, when I talk of the water demands or depletions associated with any productive activity, I'm referring to water consumption, not to water withdrawals. Water which is diverted for use but later returned to the water system is not regarded as water demanded or depleted.

Second, I will discuss in only a tangential way the indirect water demands occasioned by energy development. For example, water demands associated with the municipal growth generated by an energy development will not be regarded here as energy sector water consumption. This is not to say that such repercussions are either insignificant or unimportant. Both conventional usage and intelligent taxonomy suggest that such dimensions should be considered as part of general municipal and industrial consumption.

I will further devote most of my specific observations to those portions of New Mexico which are endowed with relatively inexpensive raw energy resources, and which are currently being developed. These areas are the San Juan Basin of Northwest New Mexico, an area which contains coal, oil, natural gas, and uranium resources; and the western New Mexico portion of the Rio Grande River Basin, noted primarily for its uranium deposits but also the site of some large coal deposits. These areas are likely to continue to be the focus of large-scale energy development in New Mexico's future. Energy development is very much tied to energy resources in the extraction phase of energy production. Beyond this, the current price structure, the physical processes involved and the regulatory structure often combine to site extensive processing facilities in the vicinity of the energy resource. Thus, we often observe coal-fired steam-electric plants and uranium mills near the minesite.

I should also mention that I will not address the New Mexican prospects for the more exotic energy technologies; either the so-called "renewables" such as solar and hot-dry-rock geothermal energy or improved transformation processes such as magnetohydrodynamics (MHD) and the breeder reactor. This is not meant to imply that such technologies or their particular siting patterns are without merit. Rather, they are deserving of much more study and evaluation and to discuss them at this time is a larger and more speculative exercise than I care to undertake.

Let's return to the issue at hand, the relationship between energy development and drought. If water is in short supply, one of the first options an energy developer might examine is the possibility of developing "new" water. In the past, this has frequently meant the construction of new dams which smooth the seasonal and annual variations in stream runoff. The Navajo dam on the San Juan River in northwestern New Mexico, for example, was built primarily to perform such a function. It currently supplies water to the San Juan Power Plant of the Public Service Company of New Mexico, the Navajo Irrigation Project, and contracts to supply water to other proposed energy projects from this reservoir are either in force or pending. The Glen Canyon dam, while it isn't in New Mexico, performs a similar function for the entire Upper Colorado River Basin, including northwest New Mexico.

This method of increasing the water supply does have physical, legal, and economic limits. One can only "develop" that amount of water which falls as precipitation and, in an arid to semi-arid state such as New Mexico, the small amount of raw water per unit of land restricts water development options. Moreover, the greater the surface area of water stored behind dams, the greater the amount of water which evaporates and which is thereby withdrawn from possible use. The legal limits on this type of water supply enhancement are numerous, but good examples may be found in New Mexico's interbasin, interstate and international agreements to deliver some of the water which runs in its rivers to out-of-state locations. "Developing" this water wouldn't improve New Mexico's water supply unless its downstream obligations were renegotiated. Finally, the economic limits on this method of water supply enhancement have been reached for the present. There are apparently no remaining sites in New Mexico where the benefits associated with the additional water developed by constructing reservoirs come close to matching the costs involved.[1]

[1] A recent Bureau of Reclamation study cited only one proposed energy project in New Mexico for which significant data was available; a pumped-storage hydroelectric plant near Elephant Butte Reservoir. This facility had a benefit/cost ratio of .54 and, while the study addressed only facilities which would produce energy directly, most large-scale water development reservoirs include some hydroelectric capacity.

The estimated surface water supply situation in New Mexico in 1975 is summarized in Table 1. This table, adopted from the "Westwide Report," shows how very close we in New Mexico are to exhausting our average annual surface water supplies. This makes us much more vulnerable to water shortages in years of less than average precipitation and provides the basis for much of the current concern over water use and allocation.

Another source of increased water supplies is sub-surface or ground water. The sponsor of an energy development project will very likely consider the option of sinking wells and pumping water to the surface. This practice, however, is limited by three considerations; the effect of such activity on surface water supplies (will it reduce surface runoff downstream), the quality of water brought to the surface (is the water of high enough quality for the use intended) and the cost of producing and transporting the ground water resource. These considerations are often interdependent and, in New Mexico at least, they work against the adaptation of sub-surface water resources by energy projects in New Mexico. As surface water supplies become tighter due to either drought or allocation schemes, however, ground water development for energy and non-energy uses will undoubtedly become more attractive despite the cost and quality considerations.

There are other, more exotic methods of enhancing water supplies which are currently being discussed for the western US. Examples include transbasin diversions, weather modification, and desalinization. While they all have their advocates, I believe that these are fairly remote water supply alternatives. The point I wish to make is that it is unlikely that in the near term the relative scarcity of water will be alleviated by supplementing the current

TABLE 1

—Estimated 1975 surface water-related situation in New Mexico
(1,000 acre-feet)

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within subregion or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Rio Grande									
Rio Grande	315	639	110	1,064	0	768	296	245	51
Pecos River	0	459	0	459	0	379	80	80	0
Total region	315	1,098	110	1,523	0	1,147	376	325	51
Texas-Gulf									
Brazos and Colorado (Texas)	0	14	0	14	0	14	0	0	0
Total region	0	14	0	14	0	14	0	0	0
Upper Colorado									
San Juan-Colorado	1,779	250	0	2,029	0	234	1,795	1,752	43[5]
Total region	1,779	250	0	2,029	0	234	1,795	1,752	43
Lower Colorado									
Little Colorado	0	56	0	56	0	21	35	19	16
Gila River	0	215	0	215	0	39	176	158	18[6]
Total region	0	271	0	271	0	60	211	177	34
Arkansas-White-Red									
Canadian	0	560	0	560	0	249	311	203	108
Total region	0	560	0	560	0	249	311	203	108
State summary	2,094	2,193	110	4,397	0	1,704	2,693	2,457	238

Source- U.S. Department of Interior, "Westwide Report," (April, 1975), p. 338.

[1] Modified inflow reflects the effects of depletions upstream of Statelines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Depletions related to ground-water mining removed from totals presented in "Depletions" table.
[5] Represents the remaining amount of water New Mexico can develop from the waters of the Colorado River System assuming 5.8 million acre-feet availability to the Upper Colorado River Region States adjusted for 1975 depletions; San Juan-Chama export 110,000 acre-feet; and Navajo Indian Irrigation project, 226,000 acre-feet; and Animas-La Plata project, 34,000 acre-feet.
[6] Additional development permitted by Colorado River Basin Project Act P.L. 90-537.

water supply. In economic parlance, the state as a whole is at a point on the supply schedule for water which is highly price inelastic; small additions to the supply of water are very expensive.

The sponsor of an energy development, then, is likely to find it more effective to examine alternatives on the so-called demand side of the water market. These alternatives may be roughly organized into two classes; factor substitution and price competition.

Factor substitution involves organizing the process of producing energy so as to reduce the water consumption per unit of output. Such a process design will involve increased uses of other resources such as capital equipment, labor and raw materials. In effect, then, the producer is substituting these resources or factors of production for water, hence the term factor substitution. Such substitution will result in higher unit costs of production if the previously envisioned, water intensive production process represents the minimum cost alternative.

Let's pursue the possibilities for factor substitution by beginning with a review of some of the water consumption figures which are cited for various types of energy facilities. The numbers on Table 2 are taken from a wide variety of sources and cover both observed and predicted water consumption for facilities which sometimes operate under very different climatic, altitude, and feedstock conditions. Most of these numbers have been summarized before in a study by Davis and Wood of the United States Geological Survey.[2]

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[2] George H. Davis and Leonard A. Wood, "Water Demands for Expanding Energy Development," Geological Survey Circular 703 (1974).

Table 2

Water Consumption by Various Energy Technologies

GENERAL PROCESS	PROCESS SPECIFICS	WATER CONSUMPTION	NOTES
Current Technologies			
Coal Fired Steam-Electric	Wet tower cooling system	14.2 - 16.0 acre-feet/ year per megawatt capacity	Based upon 80 percent load factor and observed and proposed water consumption at large new coal fired facilities in the Four Corners area.
Nuclear Steam-Electric	Light Water Reactor	22.0 acre-feet/year per megawatt capcity	Based upon 80 percent load factor and 32 percent thermal efficiency.
Nuclear Refining	Uranium Milling	.2 acre-feet/year per megawatt of electricity produced by the electric plant consuming the fuel.	Based upon 80 percent load factor at a 1000 MW light water reactor. Annual consumption of water at the milling facility to supply this reactor with fuel is about 200 acre-feet/year, mostly from evaporation from tailing ponds.
Petroleum Refining	Based upon a sample of U.S. refineries.	12 acre-feet/year per 100,000 barrels of oil refined	An average of a highly variable set of observations. No particular load factor, refinery design, output mix, etc., applies.
Coal Mining	Includes dust control, washing, and revegetation for strip coal mining.	200-250 acre-feet per million tons of coal	Based upon estimates for strip mining to provide the feedstock for coal gasification facilities in the Four Corners area.
Petroleum Extraction, Underground Coal Mining, Uranium Mining, Rail Transportation		Negligible relative to other energy activities	
Future Technologies			
Coal Gasification	Lurgi Process with Methanization	30-40 acre-feet/100,000 barrels of oil produced	Based upon proposed water consumption for several planned gasification facilities in the southwest. Most reports employ a 90 or 91 percent load factor.
Coal Liquifaction	H-Coal, Consol, COED, solvent refining	55-360 acre-feet/100,000 barrels of oil produced	These numbers are extremely tentative and vary enormously with the assumptions and technology chosen. The National Petroleum Council prefers the lower value.
Coal Transportation by Pipeline	Slurry Pipeline	600 acre-feet per 10^6 tons of coal	Taken from an estimate for a slurry pipeline in the Northern Great Plains.

While it is possible for all of these technologies to reduce water consumption as a result of factor substitution, it is most efficacious if we turn our attention to those technologies which consume large amounts of water relative to their energy production. The technologies which stand out in this regard are coal transportation by slurry pipeline, coal-fired steam-electric, nuclear steam-electric, coal gasification and coal liquefaction.

With regard to coal transportation by slurry pipeline, one might speculate upon the possibility of using other fluids, perhaps in combination with water. The most likely type of water saving factor substitution in the case of slurry pipelines, however, is simply the use of a railroad to ship the coal.

Coal-fired steam-electric and nuclear steam-electric facilities employ essentially the same cooling cycle and are therefore subject to the same factor substitution. In these technologies, capital equipment substitutes for some of the water; hybrid wet/dry cooling towers or dry cooling towers replace the more conventional wet cooling towers of these facilities. In the extreme, dry cooling towers may reduce water consumption by between three and thirty-three percent of the amount of water consumed by steam-electric plants cooled by wet towers.[3] The Public Service Company's San Juan Units 3 and 4 have hybrid cooling systems and can potentially operate on ten percent of their usual ration of water.[4]

Such factor substitution can be costly from both a physical and financial point of view, however. These water saving technologies can reduce the thermal efficiency of the power plant and thereby lower the effective plant capacity. In addition, a Water Purification Associates (WPA) study suggests that adopting

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[3] US Department of Interior, "Westwide Study Report on Critical Water Problems Facing the Eleven Western States," p. 79 (April 1973).

[4] Personal communication from Public Service Company of New Mexico, March 28, 1977.

a dry cooling system in the Four Corners area is only cost-effective when the price of water is in the neighborhood of $700 per acre-foot.[5] This is about two orders of magnitude larger than the current price of water in this area of New Mexico.

The coal gasification and coal liquefaction technologies could reduce their cooling water requirements by up to 50 percent if some air or dry cooling systems were designed into the process. Here again, however, this substitution imposes stiff economic penalties. WPA estimates that the price of water would have to be $300 to $500 per acre-foot if the increased capital and operating costs are to be justified.[6]

Now let's examine the other demand side alternative of the energy developer; price competition. Price competition involves the purchase of more water for use in the production process by out-bidding other potential users of water resources. In this case the production process remains the same or nearly the same. Since the price of one of the inputs into the production process may increase, however, this alternative may also entail an increase in the unit cost of production.

The effect of such competition on the price of water depends, to a large extent, on the institutional structure in which the market for water is imbedded and the current composition of water demand. The former consideration is outside the scope of this paper and I believe it is being examined in the other presentations. The role of the energy sector in current water consumption, however, is properly a part of this paper.

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[5] Water Purification Associates, "Water Requirements for Steam Electric Power Generation and Synthetic Fuel Plants in the Western United States," Report to the Science and Public Policy Program, University of Oklahoma, p.12 (August 1976).

[6] Water Purification Associates, "Water Requirements," p.13.

Table 3 has been adapted from the Westwide Report. It shows in a fairly gross way what the estimated water consumption was for various types of productive activity in New Mexico in 1975. The regions of particular interest are the San Juan and Rio Grande.

The San Juan region's thermal electric sector used 16.7 percent and minerals production used 2.7 percent of the water consumed net of reservoir evaporation in 1975. Irrigated agriculture, on the other hand, consumed 68 percent of the water depletions net of reservoir evaporation. This is the only region where the relative balance of water consumption between the energy sectors and irrigated agriculture is weighted as heavily toward energy, yet irrigated agriculture still consumes more than 3 times the water that energy does. Using the same method to determine relative water consumption in the Rio Grande region, we find that irrigated agriculture consumes more than 19 times as much water as energy developments. It should be clear then, that while energy production is currently a significant consumer of water, it is far from the dominant consumer of water in even those regions where it is most extensively developed. This, in turn, suggests that energy development has a great deal of latitude for employing price competition to obtain additional water supplies currently employed in other uses, especially irrigated agriculture.

What does each price competition imply for agriculture activity in the impacted areas? A recent study of water and agriculture in the San Juan region was conducted jointly by New Mexico State University and the University of New Mexico and funded by the Los Alamos Scientific Laboratory.[7] The results of this study suggest that factor substitution for water in agriculture comes

[7] Gisser, Micha, et al, "The Energy Crisis and Its Impact on the Farm Sector in the Southwest," preliminary draft.

TABLE 3 —*Estimated 1975 total depletions*[1] *for New Mexico (1,000 acre-feet)*

Region and subregion	Purpose or cause of depletion							
	Irrigation	Municipal and Industrial including rural	Minerals	Thermal electric	Recreation[2] Fish and Wildlife	Other[5]	Reservoir evaporation	Total depletions
Rio Grande	634	72	26	7	19	16	110	884
Pecos River	392	16	9	1	7	13	61	499
Total region	1,026	88	35	8	26	29	171	1,383
Texas Gulf								
Brazos and Colorado (Texas)	390	11	4	5	0	3	12	425
Total region	390	11	4	5	0	3	12	425
Upper Colorado								
San Juan Colorado	102	8	4	25	6	5	84[3]	234
Total region	102	8	4	25	6	5	84	234
Lower Colorado								
Little Colorado	9	2	2	0	1	2	5	21
Gila River	59	1	6	1	1	2	9	79
Total region	68	3	8	1	2	4	14	100
Arkansas White-Red								
Canadian	203	3	1	0	22	15	55	299
Total region	203	3	1	0	22	15	55	299
State summary	1,789	113	52	39	56	56	336	2,441[4]

Source - U.S. Department of the Interior, "Westwide Report", (April, 1975, p. 337.

[1] Includes surface water, surface related ground water, and mined ground water.
[2] Exclusive of instream flow use.
[3] Includes New Mexico's share of Colorado River main stem reservoir evaporation. Average annual main stem reservoir evaporation assumed to be 520,000 acre feet, New Mexico's share, 58,000 acre feet.
[4] Surface water depletions — 1,171,000 acre feet; ground-water depletions — 1,270,000 acre-feet. The portion of the ground water that was mined is as follows: Rio Grande Region: Rio Grande Subregion, 116,000 acre feet, Pecos River Subregion, 120,000 acre feet. Texas Gulf Region: Brazos Colorado (Texas), 411,000 acre-feet; Lower Colorado Region, Gila Subregion, 40,000 acre feet, Arkansas White-Red Region: Canadian Subregion, 50,000 acrefeet.

more easily than it does in electric generation. Agriculture would adopt more capital and labor intensive methods of applying water and change the amount of the various crops grown. As a result, agricultural income and acreage would be reduced, but this reduction would be only a small fraction of the reduction in water consumption. These results, of course, assume that an efficient market exists for the sale of water rights from one type of beneficial use to another.

If the question of water supplies for energy can be resolved by so simple a device as price competition, why does water for energy development attract so much attention? I believe there are several reasons for this concern. I'll note some of them here and defer reference to others until later in this talk. First, I believe that large scale energy projects are being implemented and planned at a time when New Mexico is just facing the real pinch so far as its water supply is concerned. Second, energy facilities are not only competing for water with irrigated agriculture, which is a major and historic force in the state's economy, but with other growing demands for water. Municipal water demand, spurred by New Mexico's rapid growth in population and economic activity, is growing rapidly. Another new demand for water relates to in-stream water requirements. The beneficial aspects of these non-consumptive uses for fish, wildlife, and recreation are beginning to attain legal status in parts of the west. Third, there is an element of provincialism at work, since energy products will in many cases be exported out of the state. Finally, the large scale and water "hunger" of the proposed energy developments suggests that they will overwhelm the rest of the local economy.

How large an increase in the energy sector's consumption of water are we looking at in New Mexico? There are, of course, many projections of future development to choose from. All are highly uncertain and subject to rapid change. In an attempt to determine an upper bound on this water demand in northwest New Mexico, all the facilities cited in a Bureau of Mines report on planned, proposed, and expanded energy facilities were assumed to have been built.[8] In addition, all of these facilities were assumed to consume the maximum amount of water per unit of output as presented in Table 1. It was found that this method yielded a projected additional water demand of 120,000 acre-feet in the San Juan region and 10,000 acre-feet in the Rio Grande region.

The figure estimated for the San Juan region is indeed frightening, since it would seem to imply at least a 75 percent reduction in water supplies to irrigated agriculture in this portion of New Mexico exclusive of the Navajo Indian Irrigation Project and the Animas-La Plata Project. A large portion of this projected increase in the demand for water, about 71,000 acre-feet, derives from two very tenuous coal gasification projects. Another 5,400 acre-feet derive from two slurry pipelines. If these projects were canceled, the planned coal-fired steam-electric projects and a 85 x 10^6 ton a year increase in so-called labor-rich coal mining activities could be accomodated by 42,000 acre-feet of water annually, a figure which is just less than the average net water supply still available to New Mexico in the San Juan region as shown in Table I.

In the Rio Grande region, the increased water consumption in due to a projected doubling in uranium milling capacity. While such an increase in milling activity may indeed exacerbate water quality problems in the region, the raw water demands to the mills will probably be met by water discharged from the uranium mines themselves.

[8] US Department of the Interior, "Projects to Expand Fuel Resources in the Western States," Bureau of Mines Information Circular, IC 8719, pp.105-115 (May 1976).

These observations suggest that for at least the foreseeable future, a judicious mix of low water consuming energy developments and some sale of water supplies by irrigated agriculture to other water consuming sectors would allow the state's energy development to grow quite rapidly without severely reducing the current levels of agricultural activity or constraining the growth of other sector activity. In fact, with the water supplies slated for the Navajo Indian and Animas-La Plata Irrigation projects, we very well might witness a concurrent increase in agricultural activity in northwestern New Mexico.

This is, to be sure, a rather sanguine note on which to conclude a talk on the interplay of water resources and energy development in New Mexico. Remember, however, that the conclusion is contingent upon efficient water markets and judicious public choice. Both of these elements are, in turn, dependent on public water policy and the question of public policy brings us to another reason for why the role of water resources in energy development receives so much attention.

As I mentioned earlier, we are now in a period when water supplies are becoming very expensive. At the same time, there is a precedent for extensive and active public sector participation in the area of water resources policy. In effect, the leverage of public water resources policy has increased and the prospect that this leverage will be used as a tool for the achievement of broader social and political objectives increases accordingly. I think it is this prospect which generates so much interest in the energy dimension of water resources policy. It is this prospect which adds the shrill tone to the debate over the use of water resources for energy development.